SVACH

CPR Meeting #1

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Iain Walker
Brennan Less
Jordan Clark
Spencer Dutton
Xiwang Li

Project Background

- On the path to ZNE homes air tightness is increasing
  - Less natural infiltration
- Need to ensure that IAQ is maintained
  - More mechanical ventilation
- This project will develop:

1. Smart ventilation technologies to allow for mechanical ventilation while reducing energy and peak demand
2. IAQ metrics to allow for optimizing ventilation
   - E.g., Comparing difference pollutants or allowing zonal approaches

- Phase I – generic contaminants (e.g., ASHRAE 62.2)
- Phase II – specific contaminants of concern

Technical Project Tasks

1. State of the Art Review
2. IAQ Metrics
   - Getting beyond air flow requirements
   - In collaboration with DOE efforts
3. Single Zone Technology Evaluation
   - Find ways to better ventilate high performance California homes
   - Save energy and reduce peak demand
   - Maintain or improve IAQ
4. Multi-Zone Technology Evaluation
   - Are there better ways to ventilate if homes are zoned for ventilation like they are for heating/cooling?

Task 1 - State of the Art Review

- Completed Report: *Residential Smart Ventilation: A Review* (LBNL 2001056)
- Presentation and report at 2017 AIVC conference: *A Review of Pollutants and Sources of Concern and Performance-Based Approaches to Residential Smart Ventilation*
- Journal articles in process:
  - *Smart ventilation energy and indoor air quality performance in residential buildings: a review*. Accepted for Energy and Buildings
  - *Performance based approaches for smart ventilation in residential buildings*. Submitted to International Journal of Ventilation
- Almost 200 papers and articles reviewed
- Many international
  - Mostly Demand Controlled Ventilation (DCV)
  - DCV based on RH & CO_2 as surrogates for occupant-related pollutants and building occupancy
- Non-DCV systems currently very rare
- Limited success using outdoor temperature and TVOC-based controls
- Using other pollutants currently too expensive and not accurate enough

Task 1 - State of the Art Review

- Contaminants of concern:
  - For chronic exposure: PM, NO2, Formaldehyde, Acrolein, moisture (mold)
  - For acute exposure: PM, NO2, CO (?)
  - Other issues: smoking & Radon
- Sensor technologies:
  - CO_2 and RH are affordable and available
  - TVOC: not very useful: which VOCs? At what concentration?
  - Particles: Getting cheaper – but considerable concern about accuracy of low-cost sensors
  - Individual VOCs: Getting cheaper – but considerable concern about accuracy of low-cost sensors

Task 1 - State of the Art Review
Energy Saving Strategies

- **Current:** Turn off systems when unoccupied – very popular in Europe
  - Use CO_2 and RH as a surrogate for occupancy
  - Mostly ignores any non-occupant generated pollutants – very different from ASHRAE 62.2 Equivalency approach (assumes constant emission)
  - Sometimes have a low baseline ventilation rather than completely off
- **Emerging:** smarter controls based on
  - Timers to avoid known higher temperature differences
  - Measured outdoor T and/or RH
    - Onsite much harder to get right than remote access, sensor location critical
    - Remote access not 100% guaranteed – so need a good default

Task 1 - State of the Art Review
Multizone

- **Current controls & approaches almost exclusively single zone**
- Studies show tighter more energy efficient homes have room to room differences
  - Less natural infiltration & forced air system operation so less mixing
  - Is mixing a solution: I stink or you stink?
  - Highly dependent on door opening and ventilation system
  - Material emissions have little variation
  - CO_2, RH and other occupant-related sources more variation
  - Two likely scenarios that might be useful:
    1. Bedrooms with closed doors tend to have higher CO_2 and RH (and related bioeffluents)
    2. Closing doors and isolating kitchens, bathrooms and laundry rooms might be a good idea (no mixing)

Task 1- State of the art review Emerging Regulation In the US

1. ASHRAE 62.2 – Ventilation Equivalence
   - Equivalent ventilation allows time varying air flow to show equivalence to constant air flow specification
2. IAQ “Equivalence” – not just air flow
   - Identify Unit Damage Estimate based on DALYs
   - Multiply concentration by UDE to get DALYS and sum over contaminants

Compound	UDE $\left[\frac{\mu DALYS}{year*person} * \frac{m^3}{\mu g}\right]$	Chronic Standard $\left[\frac{\mu g}{m^3}\right]$	Chronic Standard damage $\left[\frac{\mu DALYS}{year*person}\right]$
Priority Pollutants			
1,3 Butadiene	0.02	0.06	0.001
1,4-dichlorobenzene	0.03	0.91	0.024
Acetaldehyde	0.3	3.7	0.96
Acrolein	190	0.02	3.7
Benzene	0.08	0.34	0.025
Formaldehyde	6.8	1.7	11.4
Naphthalene	0.47	0.29	0.14
Nitrogen Dioxide	0.70	40	27
$PM_{2.5}$	500	15	7,500
Other contaminants			
Ammonia	0.23	200	46
Ozone	1.4	147	200
Crotonaldehyde	1.02	N/A	N/A

Set limits of: 8200 μDaly per person per year

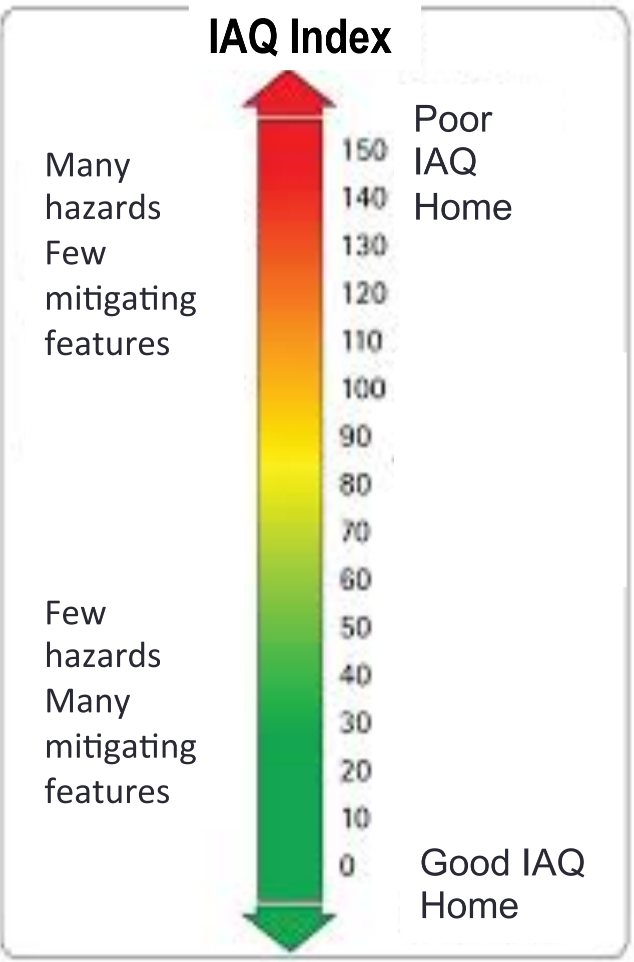
Or 90 μDaly per person per year without PM

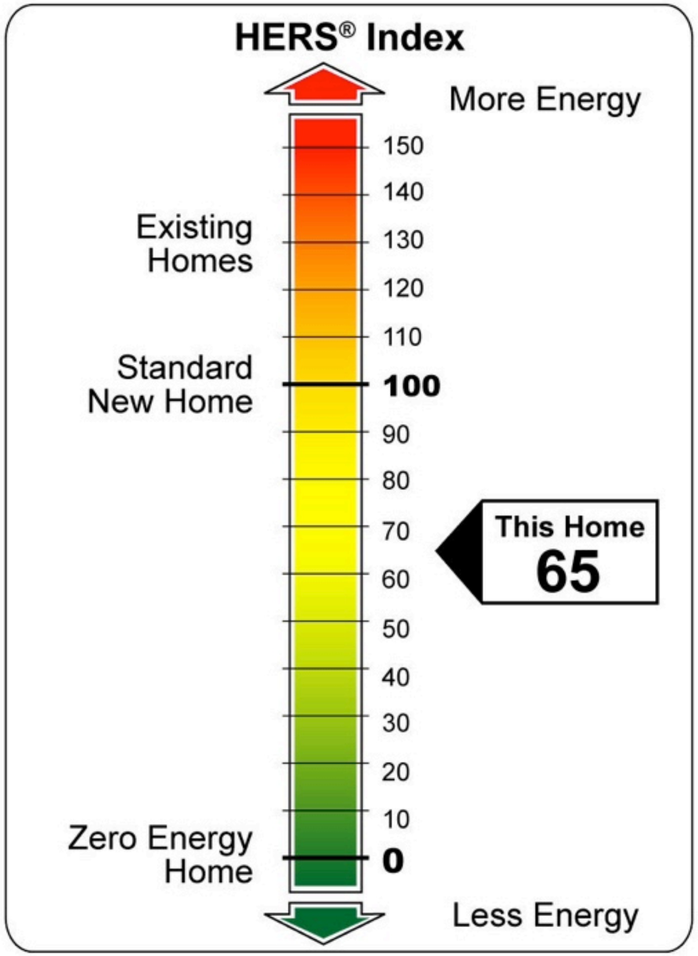
Is PM too dominant????

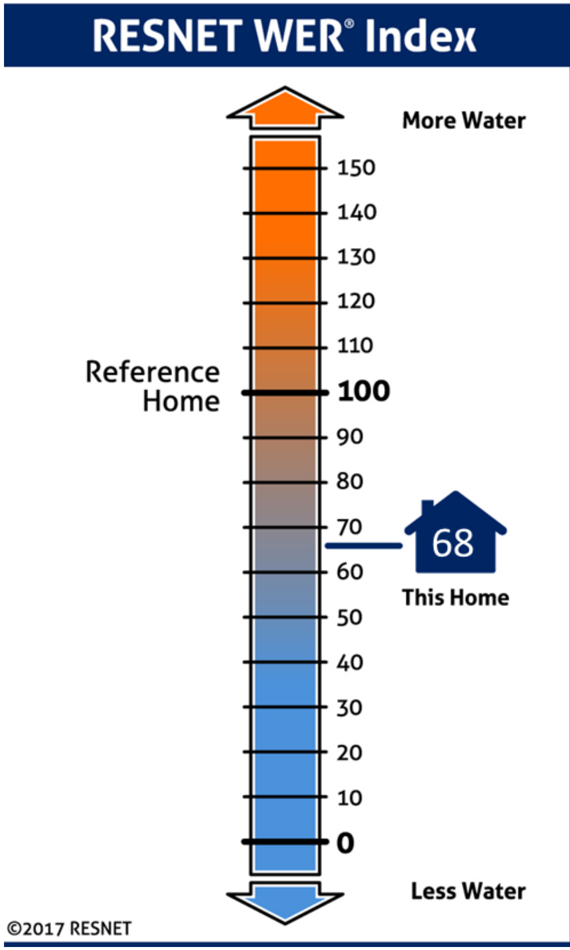
Task 2 - IAQ Metrics Quantitative Rating

- Completed report: *Indoor Air Quality Evaluation*
- **Phase I** metrics suitable for technology evaluation
  - Relative exposure: compare alternative ventilation approaches to a reference ventilation system assuming same pollutants.
  - **ASHRAE 62.2-based**: exposure to a generic contaminant
  - New metrics to separate contaminants from occupant activities and from those continuously emitted by building materials and furnishings – linked to occupancy based ventilation control study for DOE
- Expand metrics to be suitable for **Phase II** technology evaluation
  - Method 1: Compare measured exposure concentrations to existing exposure standards or Exposure Limit Values
  - Method 2: Evaluate direct health impacts of contaminants through the estimation of Disability-Adjusted Life Years (DALYs) – DOE support of IAQ Score
- Appraisal industry strongly supports a “score”

Task 2 – IAQ Metrics
IAQ Index – Like a HERS for IAQ







Task 2 – IAQ Metrics
IAQ Index - Methodology

Identify potential hazards that add points to the index score

Identify Home features that mitigate hazards and subtract points, e.g.,

- A good filtration system would subtract points
- A lack of kitchen ventilation would add points

Magnitude of points based on:

- the hazard level
- how much the feature mitigates the hazard, and
- the effectiveness of the mitigation strategy

Combine three separate sub-scores: health, odor, moisture

- Health based on DALYS - Odor and moisture less clear

Draft Calculator – ready for field Beta-testing

Task 3 – Single Zone Technology Evaluation

- Over to Brennan ….

Smart Ventilation Controls

- Time shifting:
  - Temperature SVC (TSVC)
- Reducing total air flow
  - Occupancy SVC (OSVC)
  - Auxiliary Fan SVC (ASVC)

Simulation Parameters

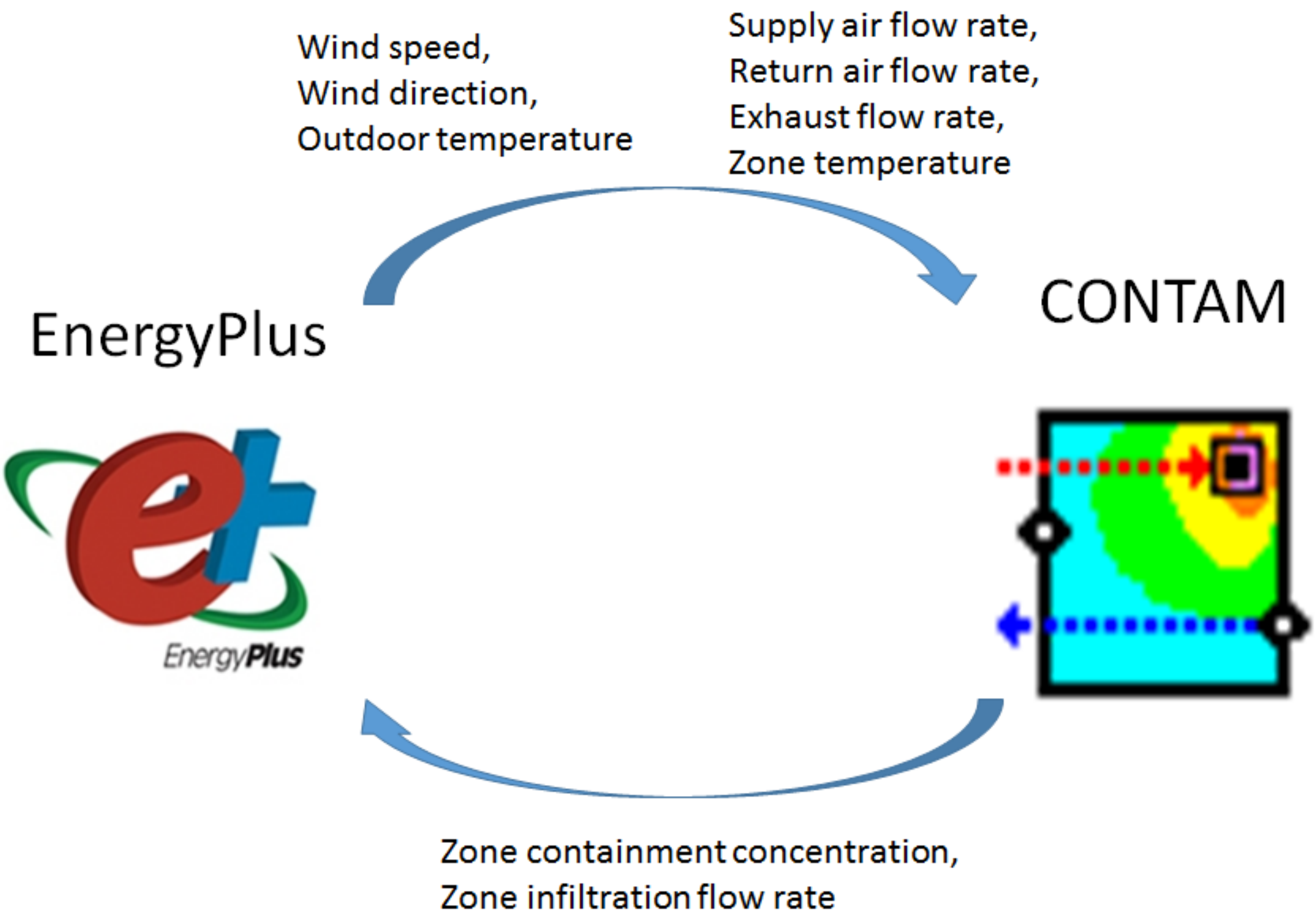
- Prototype Homes
  - 1-story
  - 2-story
- CEC Climate Zones
  - 1, 3, 10 and 16
- Envelope Airtightness (ACH_{50})
  - 1,3 and 5
  - Exhaust fans in 3 and 5; Balanced fans in 1 ACH_{50} cases
- Smart Ventilation Controls (SVC)
  - Baseline (fan and no fan)
  - Temperature (n=6)
  - Occupancy (n=3)
  - Auxiliary Fans
- Infiltration Assumption
  - Q_{inf} - constant all year based on tabulated 62.2 parameters
  - AIM-2 - variable with temperature and windspeed

Current simulation set, n = 735

Title 24 (2016) compliant new prototype homes

Higher equipment efficiency 92% AFUE, EER 12.8 (suggested by TAC)

Simulation Framework



Challenges

- Co-Simulation of energy and airflow/IAQ software (EnergyPlus and CONTAM)
- Providing apples-apples comparison
- Complex interactions between fan sizing, climate, infiltration, and control strategies
- Pre-calculating optimal control points
- “Real” vs. controller (62.2) exposure

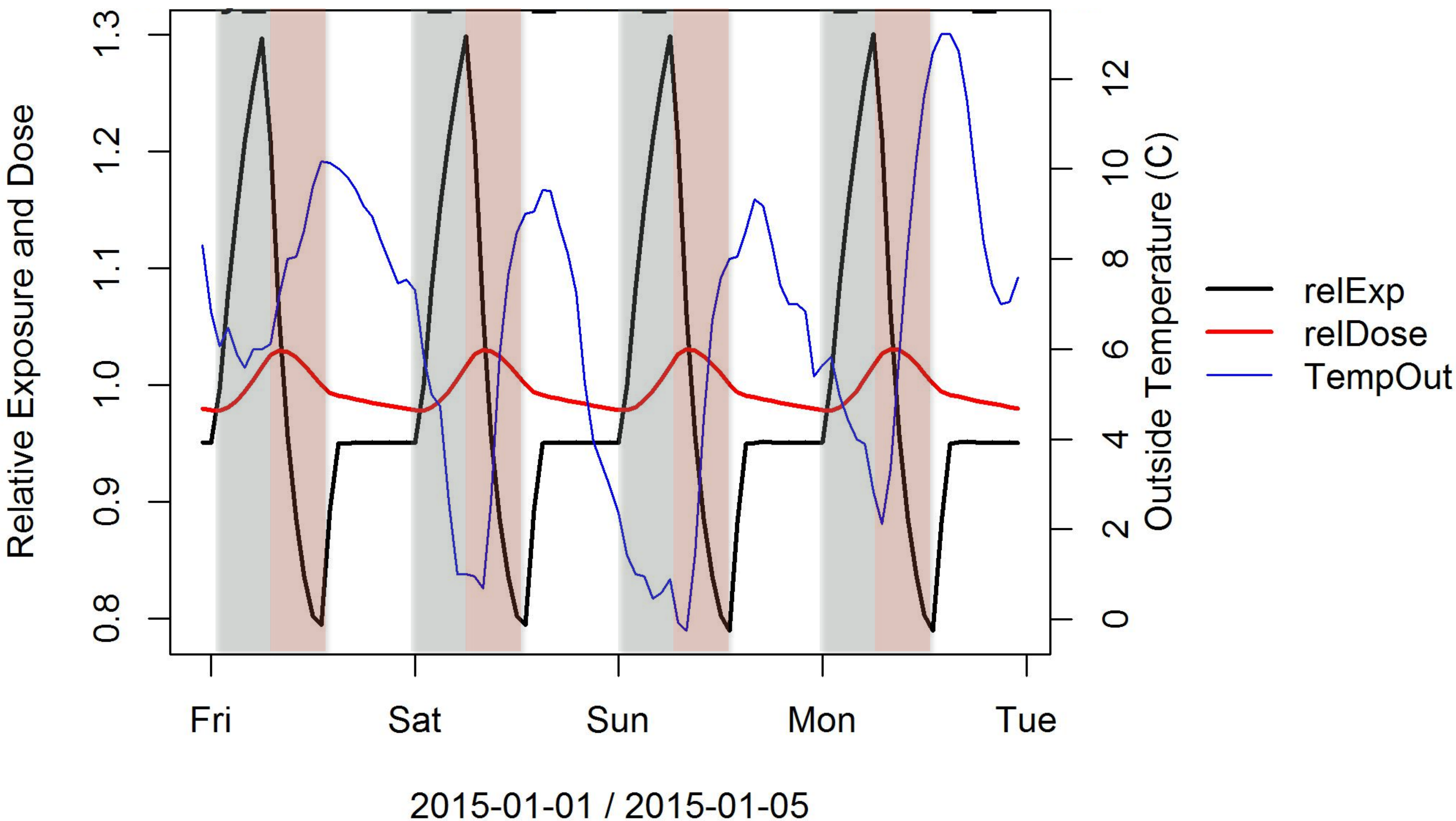
Temperature Controls (TSVC)

- Timer-based Lockout
  - 4-, 6- and 8-hour lockout periods
  - Requires no outdoor temperature sensor
- Seasonal
  - Increase/decrease ventilation rate by Season (heating vs. cooling)
- Running Median
  - 3-, 7-, 30- and 365-day running median control points
- Cutoff
  - Seasonal targets, plus cutoff for each season with high and low target RE
- Proportional
  - Variable Airflow
  - Variable RE target

Control Parameters Optimized by m*cp*dT estimates

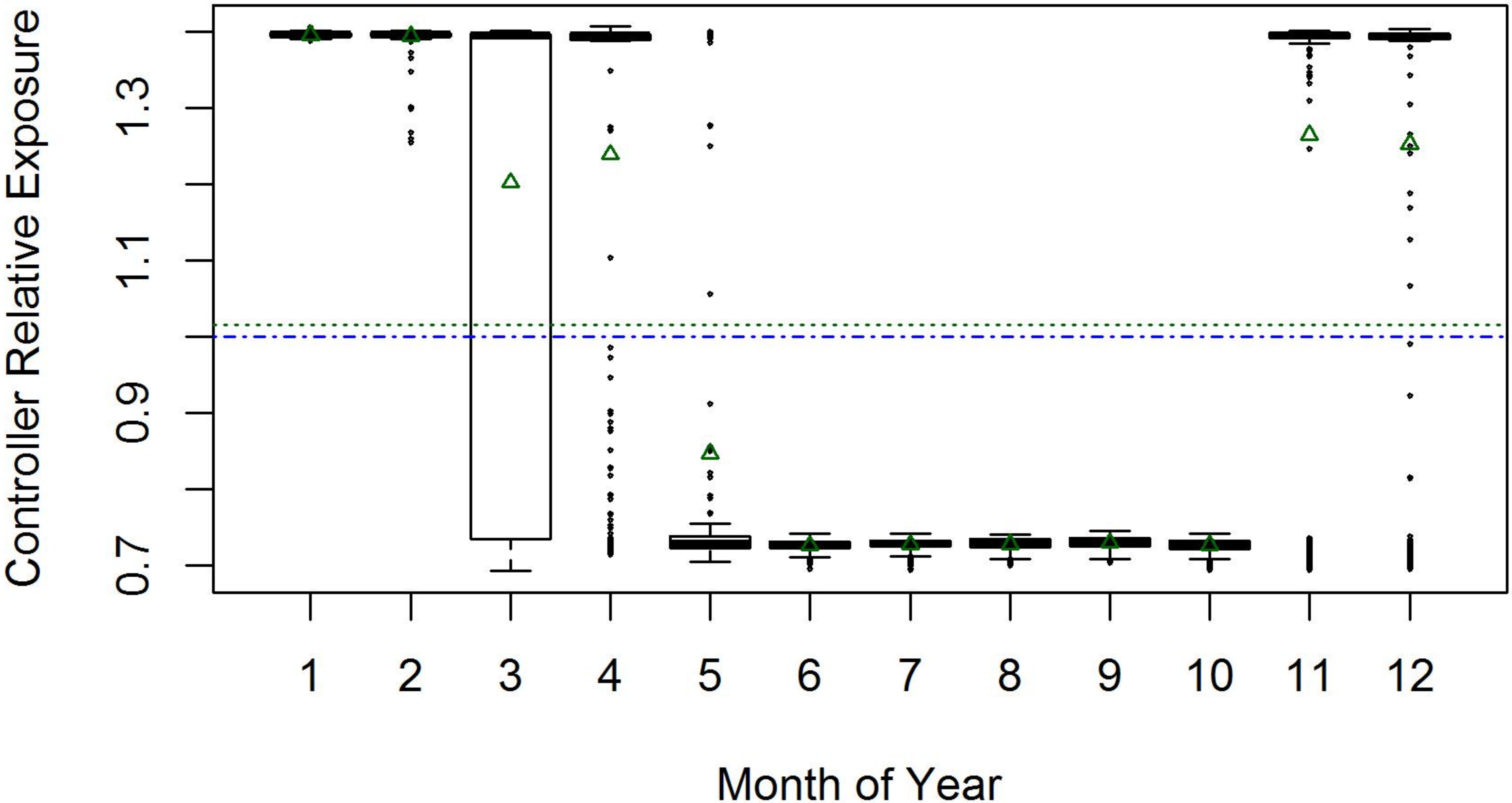
Timer-based Lockout

Pre-calculated warmest and coldest hours of the average day, daily dose = 1.



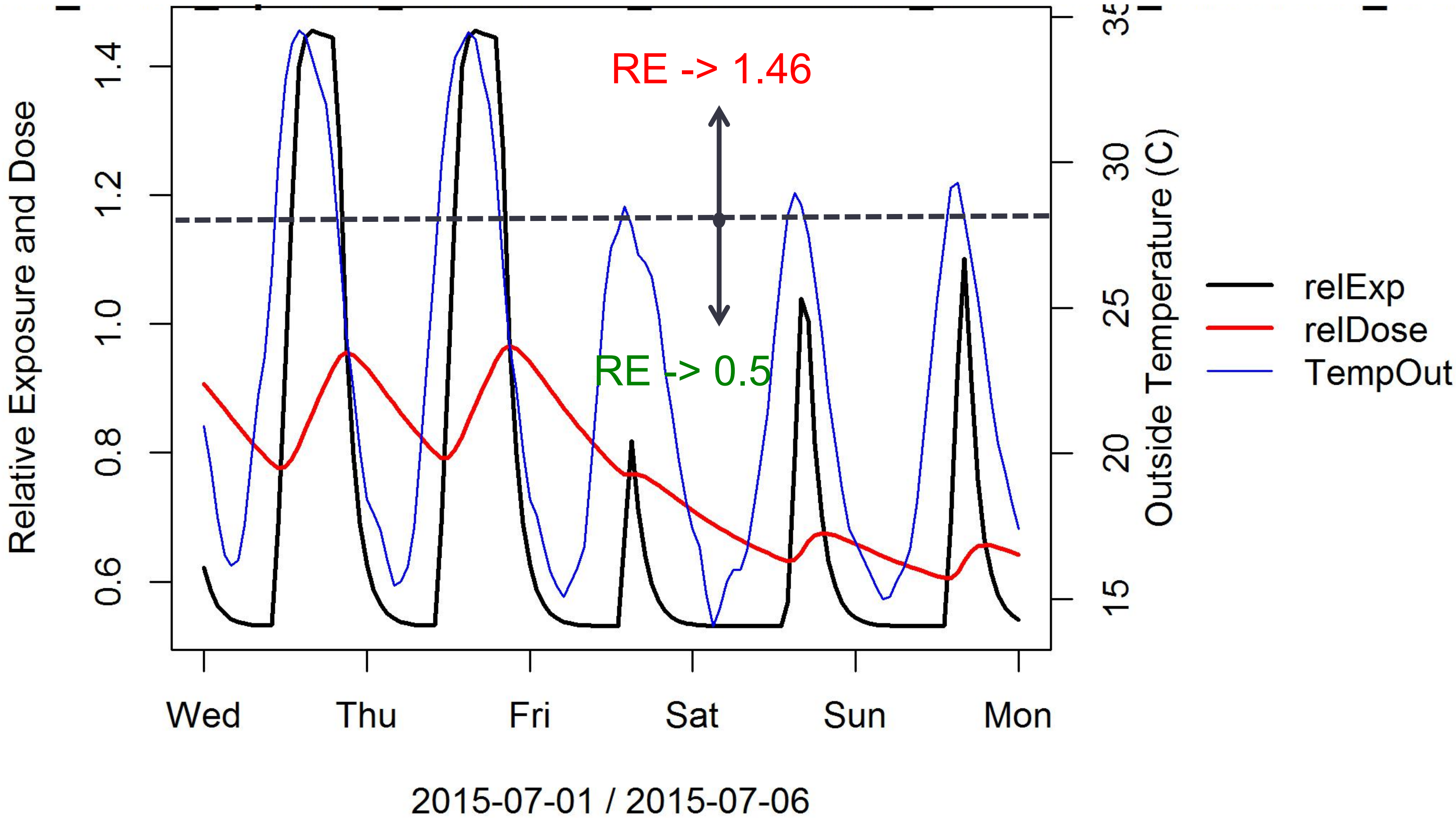
Seasonal

Exposure targets differ in "heating" vs. "cooling" season, based on weighted average
Heating and cooling defined by T24 metric

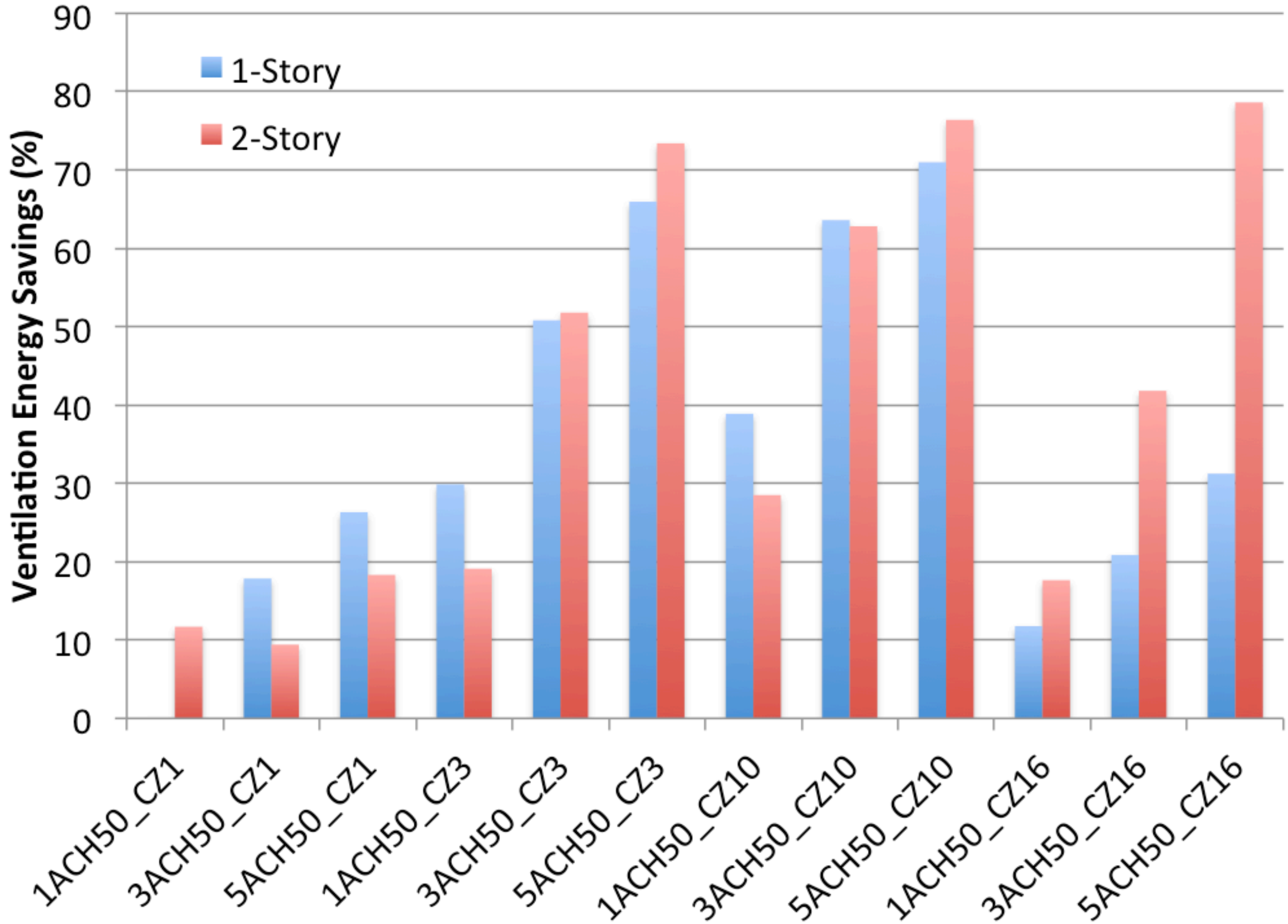


Cutoff Illustration

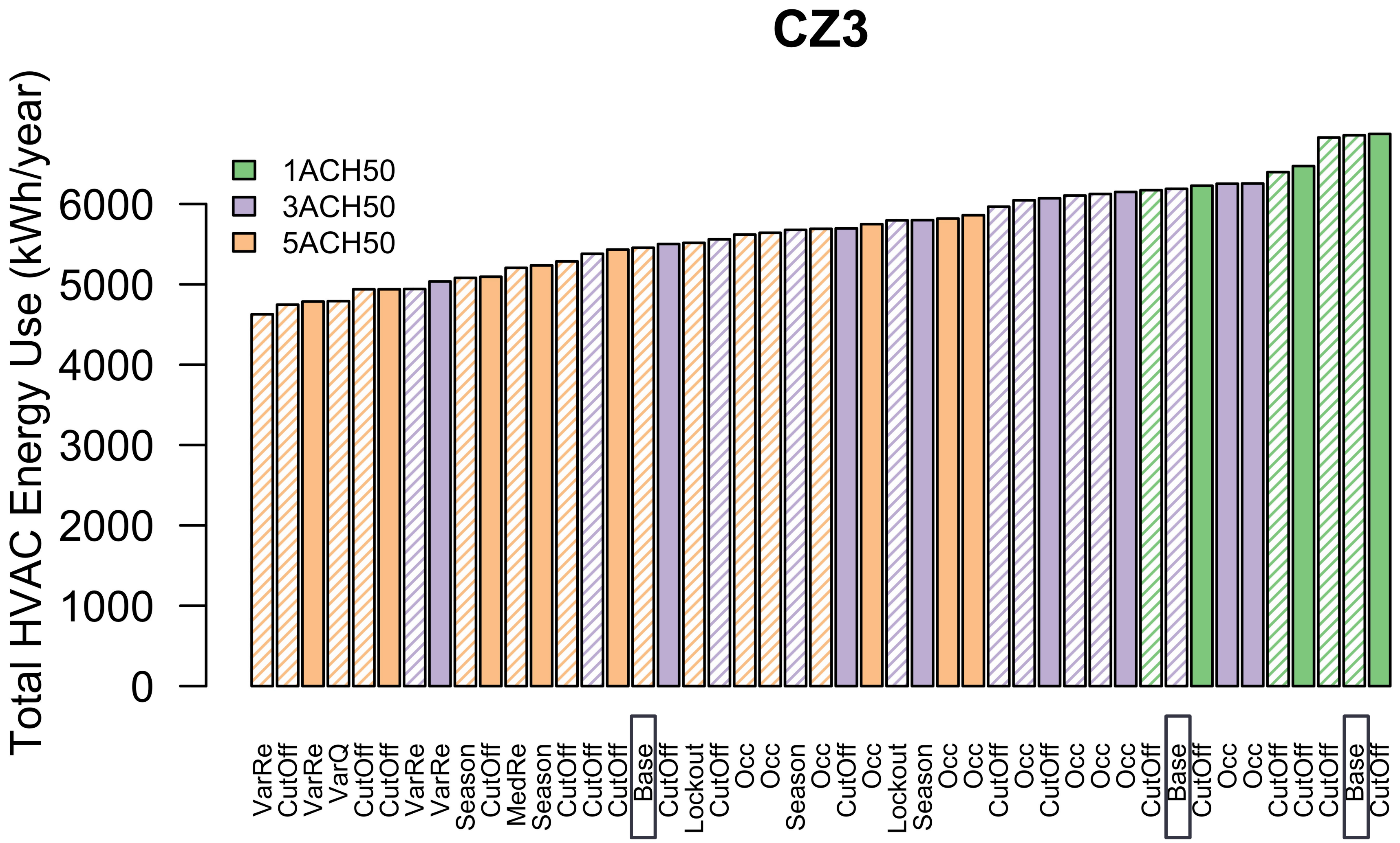
Change Re target based on outside temperature



Maximum Ventilation Saving Strategies



Sorted Total HVAC Consumption



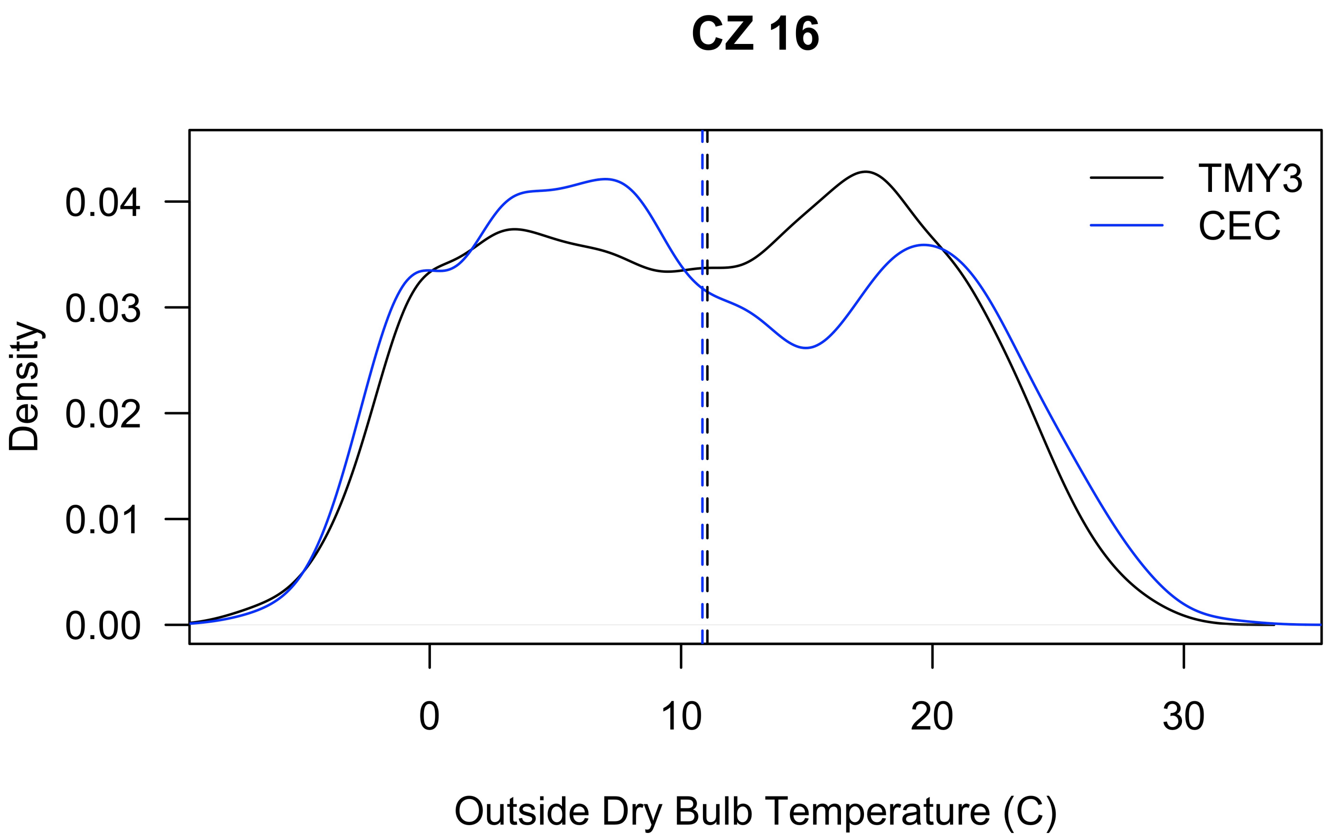
Why Do Leaky Homes Use Less Energy?

CZ 3 1 story			
Tightness	Mean ACH	Actual RE	Energy kWh
1 ACH50	0.30	0.98	4844
3 ACH50	0.27	1.09	4523
5 ACH50	0.24	1.23	4438

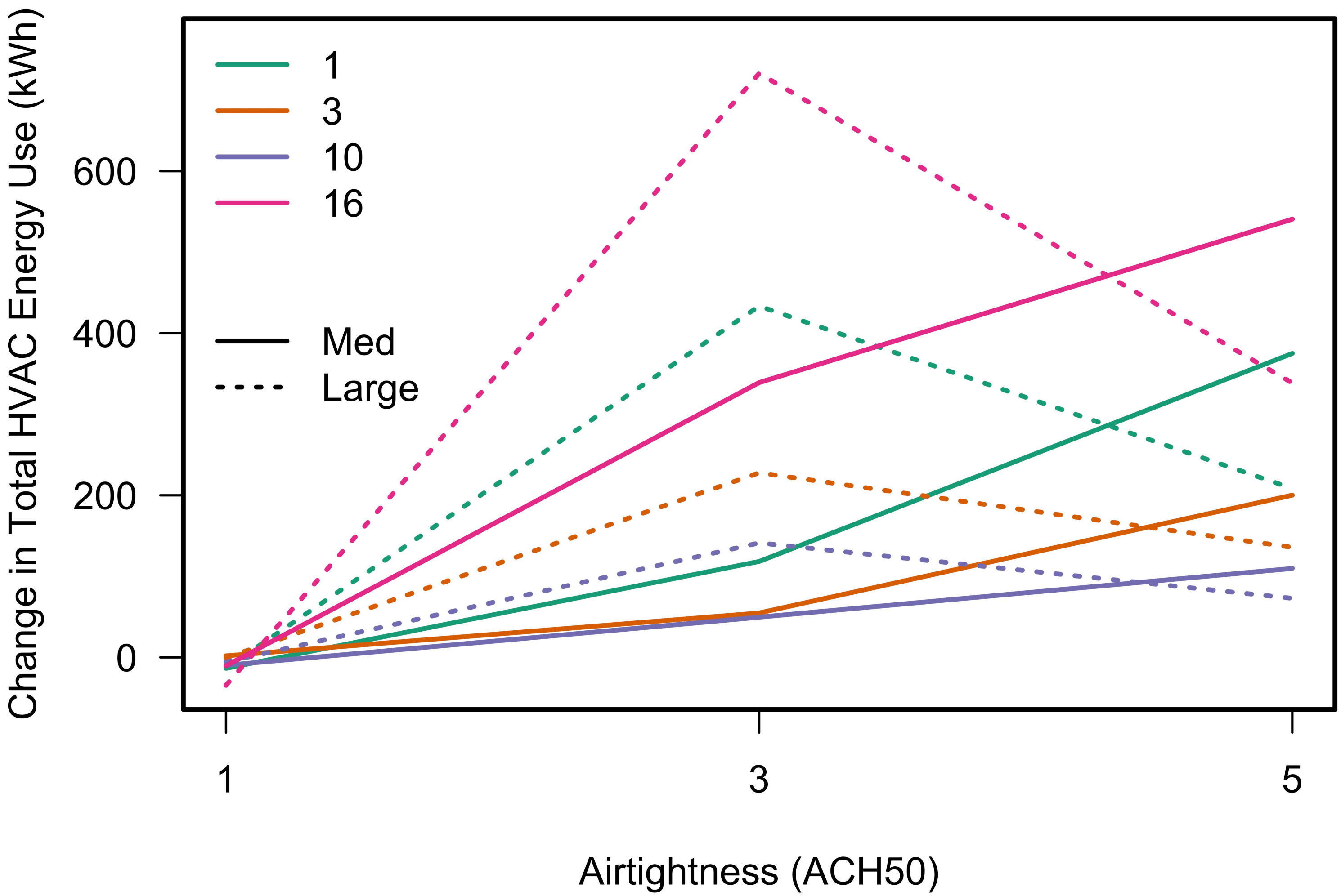
- Infiltration assumptions in ASHRAE 62.2 fan sizing methods do not match T24
  - Different weather data
  - Different house leakage distribution (50% in ceiling)
  - Leads to higher infiltration and a smaller fan than actually needed
- Differences between superposition to determine fan size with superposition to determine combined fan and infiltration flow

Why Do Leaky Homes Use Less Energy?

- Different weather: TMY3 used for 62.2 weather factors and fan sizing



Changes in HVAC Energy Use With New Distribution - HENGH



Solutions for Apples-to-Apples Comparisons

- Size baseline fans for internal consistency:
    - Calculate custom infiltration factors using E+/CONTAM.
- Change assumed leakage distribution to match 62.2
- Generate infiltration factors used in fan sizing that align with T24 weather data and leakage distribution.

Task 4 – Multizone Technology Evaluation

- Simulation software set up for multi-zone
- Using same package developed for single zone to allow direct comparison

US DOE Technical Support

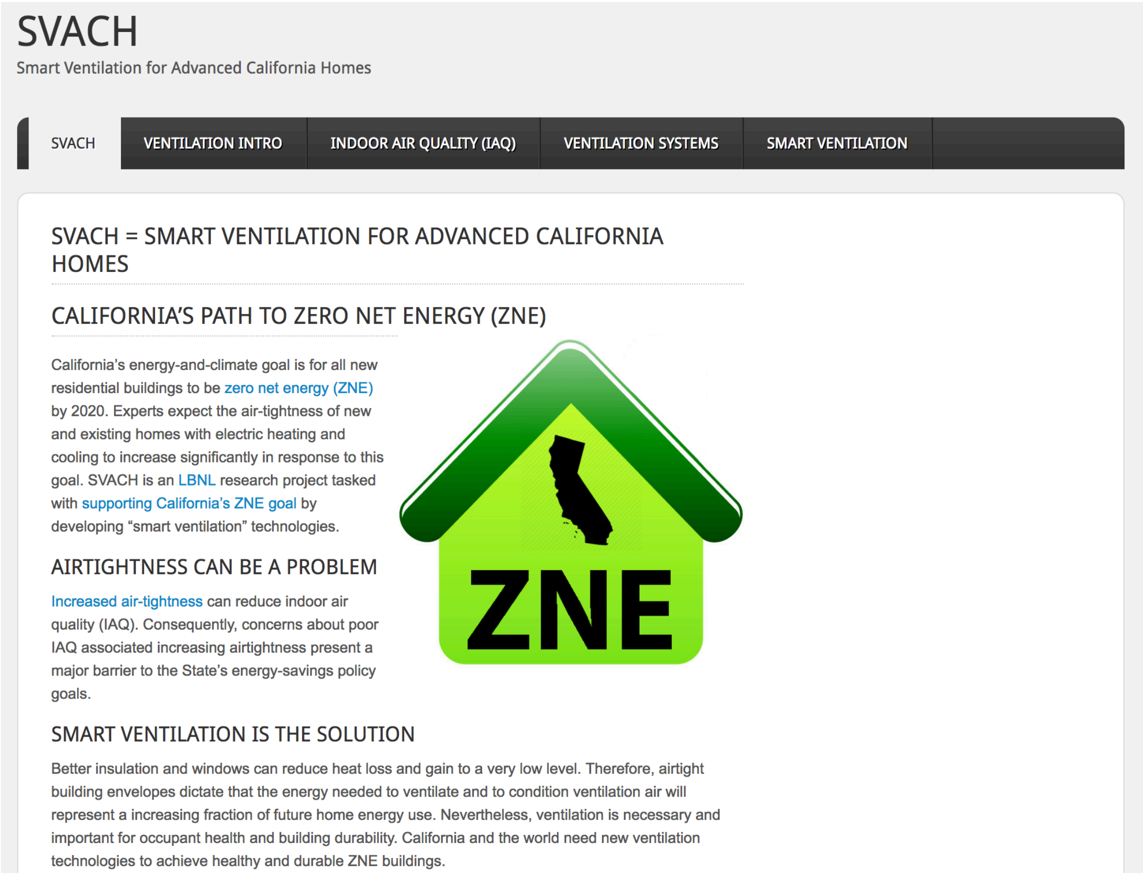
- Support for: smart ventilation algorithm development, simulation tool development, laboratory evaluation of IAQ sensors technologies, and development of IAQ score
- Travel and related support for participation in ASHRAE 62.2 development and related national (and international AIVC) meetings.
- Travel support to attend other national meetings of interest, including relevant builders’ and retrofitters’ conferences and similar events

Aereco Technical Support

- Past year - Aereco has provided input to literature review Next year - Aereco has agreed to make available appropriate test sites (and equipment) using their current technology. Aereco will also provide technical expertise on the performance of its specific equipment and, as needed, materials.

Project Management – Saturn Resource Management

- For Technology Transfer Task – created a public website to share project info: svach.lbl.gov



SVACH

Smart Ventilation for Advanced California Homes

SVACH | VENTILATION INTRO | INDOOR AIR QUALITY (IAQ) | VENTILATION SYSTEMS | SMART VENTILATION

SVACH = SMART VENTILATION FOR ADVANCED CALIFORNIA HOMES

CALIFORNIA'S PATH TO ZERO NET ENERGY (ZNE)

California's energy-and-climate goal is for all new residential buildings to be zero net energy (ZNE) by 2020. Experts expect the air-tightness of new and existing homes with electric heating and cooling to increase significantly in response to this goal. SVACH is an LBNL research project tasked with supporting California's ZNE goal by developing "smart ventilation" technologies.

AIRTIGHTNESS CAN BE A PROBLEM

Increased air-tightness can reduce indoor air quality (IAQ). Consequently, concerns about poor IAQ associated increasing airtightness present a major barrier to the State's energy-savings policy goals.

SMART VENTILATION IS THE SOLUTION

Better insulation and windows can reduce heat loss and gain to a very low level. Therefore, airtight building envelopes dictate that the energy needed to ventilate and to condition ventilation air will represent a increasing fraction of future home energy use. Nevertheless, ventilation is necessary and important for occupant health and building durability. California and the world need new ventilation technologies to achieve healthy and durable ZNE buildings.

Website background content complete

We will add project results

Budget and Scheduling

- On budget – soon to have Aereco funding
- Catching up after late start
- Next steps:
  - Complete Phase I simulations
    - Investigate issues regarding 62.2 application to California homes
  - Plan Phase II simulations
  - Work with Aereco on multi-zone/multi-family approaches